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An Economic Analysis of Prairie Dog Control

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AN ECONOMIC ANALYSIS OF PRAIRIE DOG CONTROL

by

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Alan R. Collins

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ABSTRACT

An Economic Analysis of Prairie Dog Control

by

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Prairie dog control was found to be economically feasible on the Conata basin in South Dakota with future annual maintenance control to prevent re-invasions. The large difference between the present net worth values of the two viewpoints ($2587 for the U.S. Forest Service acting as an agent of the sovereign and $109,011 for the ranchers) was due to the added costs of environmental considerations included in the U.S. Forest Service control program, but assumed not to be included in control by ranchers. In order for prairie dog control to remain economically feasible, annual maintenance control for the U.S. Forest Service must be below 5 percent of the total initially controlled acreage in the control program (9 percent for the rancher viewpoint).

Sun sedge (*Carex heloiphila*) constituted the major cattle forage increase from control in this study while western wheatgrass (*Agropyron smithii*), the dominant mid-grass in the area, showed no increase in production after five years of prairie dog elimination. Overall, 84 pounds per acre of usable cattle forage was gained from control.

(82 pages)

INTRODUCTION

Prairie dog control has been done extensively for many years yet there has never been an economic analysis of any control method. While control has been justified on the basis of the need to reduce the potential of a plague outbreak among prairie dog populations, competition between domestic livestock and prairie dogs for range forage has usually been the main justification for control. A few research efforts have investigated this competition (Taylor and Loftfield, 1924; and Hansen and Gold, 1977), but no effort has been made to evaluate the costs and benefits of eliminating this competition by control.

This study will provide a benefit-cost analysis of prairie dog control mainly from the point of view of a public land management agency conducting the control work on public land. Data for this study will be based on the prairie dog control program currently being conducted on the Conata basin of the Wall Ranger District in South Dakota by the U.S. Forest Service (USFS) and on the forage response data collected by the Rocky Mountain Forest and Range Experiment Station in Rapid City, which sponsored this study.

Prairie dogs are not a widespread problem on the Great Plains because of the intensive efforts over the years to eliminate them from rangelands. In fact, states such as Nebraska have laws that require prairie dogs to be totally exterminated on state owned and private lands each year by a certain date. Prairie dogs would seem to be more of a local problem in specific areas of the Great Plains with one such area being the Conata basin.

In the case of the Conata basin, concern over the rapid expansion of black-tailed prairie dog (Cynomys ludovicianus) towns on the Buffalo Gap National Grassland from 1650 acres in 1968 to 15,660 acres in 1976 prompted the USFS, with pressure from the ranch operators in the area, to take action in controlling prairie dogs. An Environmental Impact Statement (EIS) for the control program was completed in 1978 and prairie dog control was started the same year. At the end of the 1980 field season, 29,168 acres had received initial treatment and 6329 acres had been retreated. The prairie dog control program is presently being conducted under year by year funding with the bulk of initial control work completed. The Fish and Game Department in the state of South Dakota has also been controlling prairie dogs on the Conata basin since 1978 and had treated a total of 5850 acres of private land as of 1979.

The Conata basin has a shortgrass vegetation type dominated by blue grama (Bouteloua gracilis) and buffalograss (Buchloe dactyloides) with the potential for a mixed grass prairie that includes western wheatgrass (Agropyron smithii) as a dominant species also. The average annual precipitation in the area is 15 to 17 inches. Most of the cattle grazing on the National Grassland in the basin is from early May to early October.

The primary objective of this study is:

- to determine the net dollar benefits from vegetation changes due to prairie dog control.

REVIEW OF LITERATURE

Early literature on prairie dog relations with cattle was overwhelmingly negative. Merriam (1901) and Bell (1920) described the losses in crops and range forage due to prairie dogs and the need to eliminate them. Taylor and Loftfield (1924) calculated that prairie dogs consumed 80 percent of the total annual production of forage in their northern Arizona study and concluded that prairie dogs seriously competed with cattle, especially during droughts.

More recent research efforts suggest that prairie dogs compete with cattle for forage, but possibly not enough to warrant control measures. Most of the major species found to be consumed by black-tailed prairie dogs are potential cattle forage (Kelso, 1939; and Bonham and Lerwick, 1976). Summers and Linder (1978) sampled a dog town near the Conata basin and found that the important food species for prairie dogs were buffalograss, scarlet globemallow (Sphaeralcae coccinea), threadleaf sedge (Carex filifolia), blue grama, and western wheatgrass. All of these species are preferred cattle forage. Hansen and Gold (1977) found sedges to be the most important food species for black-tailed prairie dogs in northeastern Colorado and the second most important species in cattle diets. In their study, cattle and prairie dog diets had the highest similarity during the spring. They estimated that prairie dogs consumed 53 kilograms per hectare (46 pounds per acre) of potential cattle forage and concluded that dog town areas were less attractive to cattle than adjacent areas.

Klatt and Hein (1978) studied plant cover on active and abandoned towns (where prairie dogs were eradicated by poisoning) and found that it was greater on active towns than on those abandoned for one, two, and five years because of greater blue grama and buffalograss cover. Although prairie dog eradicated areas improved slightly in terms of cattle grazing because of increased western wheatgrass cover, they concluded that prairie dog eradication of an area did not significantly improve shortgrass prairie for cattle grazing during the first few years.

Prairie dog grazing has been reported to increase shortgrasses and decrease taller mid-grasses. Koford (1958) cited clipping of the taller western wheatgrass as the reason to expect prairie dogs to cause buffalograss and blue grama to increase with respect to western wheatgrass. He concluded that on a mixed grass prairie the general effects of prairie dogs are to decrease western wheatgrass and to increase buffalograss over blue grama. Taylor and Loftfield (1924) noted that grazing by zuni prairie dogs favored an increase in blue grama in comparison with the mid-grasses in the area.

Prairie dog control methods other than poisoning have been reported in the literature. Snell and Hlavachick (1980) observed that four successive years of grazing deferments during the growing season substantially reduced a prairie dog town's size in Kansas on a shortgrass habitat similar to the Conata basin. But, an attempt to reduce the prairie dog population of a town in Montana by reducing forb production with a herbicide did not succeed as prairie dogs switched from largely forbs to mostly grasses in their diet (Fagerstone, Tietjen, and LaVoie, 1977).

METHODS

Benefit-cost analysis technique

Benefit-cost analysis is a method of separating out factors which need to be taken into account in making certain economic choices (Prest and Turvey, 1965). According to Prest and Turvey (1965), the general principles of a benefit-cost analysis constitue the answers to the following questions:

1) Which costs and benefits are to be included?
2) How are they valued?
3) What interest rate is used for discounting?

To determine the costs and benefits of a project a viewpoint is needed as to what costs are incurred and what benefits are received from a specific point of view. The scope or perspective of the costs and benefits included is important in a federal agency viewpoint because the costs and benefits of a project are quite different for a national perspective when compared to a regional one (McKean, 1958). Identifying the costs and benefits is done by comparing the situation with verus without the project (Gittinger, 1972). The difference is the additional net benefit from the project.

Costs and benefits are almost always valued in terms of dollars in a benefit-cost analysis. This is generally straightforward for market priced goods and services, but non-market priced and/or non-quantifiable costs and benefits are much more difficult to put a dollar value on for an analysis.[1] Although difficult to price,

[1]Valuation techniques for non-market benefits are reviewed in

non-market costs and benefits should be included in a benefit-cost analysis if they constitute an important part of the total costs and benefits. If they are small when compared to the market priced costs and benefits, they should only be acknowledged in the analysis because the cost of obtaining accurate dollar values is probably greater than the added benefit to decision making.

There are many different views as to which opportunity cost or borrowing cost the discount rate should represent (Prest and Turvey, 1965). No matter what discount rate is used, it is crucial that the rate remain consistent with the costs and benefits in regards to inflation. Either all future costs and benefits must be inflated at a projected percentage increase because inflation is accounted for in the interest rate, or all three must be based on real terms with no inflation included.

Specifically for this study, the benefit-cost analysis procedure followed to evaluate prairie dog control is outlined in Table 1. Only market priced benefits and costs were used in the calculation of the economic feasibility of control. Non-market priced and/or non-quantifiable costs and benefits are presented in the discussion section, but no attempt was made to put a dollar value on them in this study because of their minor importance when compared to the market priced benefits and costs of prairie dog control.

Only direct costs and benefits were used to evaluate prairie dog control in this study. The direct costs of control are the value of the goods and services used in the control program. The direct

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Knetsch (1963) and Knetsch and Davis (1974).

Table 1. Benefit-cost analysis procedure for prairie dog control.

I. viewpoint

   A. ranchers

   B. USFS -

II. benefits

   A. cattle forage
      1. vegetation production on a prairie dog eliminated area verus vegetation production on a prairie dog grazing area
      2. cattle forage species and cattle use percentages
      3. conversion of increased usable cattle forage into Animal Unit Months (AUMs)
      4. valuation of AUMs

   B. project life
      1. with annual maintenance control to prevent prairie dog re-invasion
      2. without annual maintenance control

III. costs

   A. actual control

   B. added due to environmental considerations

IV. evaluation of benefits and costs

   A. real discount rate

   B. economic feasibility criteria
      1. present net worth
      2. benefit-cost ratio

   C. sensitivity analysis of vegetation production data

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benefits are the value of the immediate products (AUMs) for which the direct costs were incurred (Ciriacy-Wantrup, 1955). These direct costs and benefits are the only costs and benefits accounted for in a private firm viewpoint (the ranchers).

No secondary net benefits were considered in the evaluation of control due to the national perspective taken from the federal agency viewpoint in this study. Secondary net benefits are the result of activities "stemming from" or "induced by" the AUMs gained from prairie dog control. This is also known as the multiplier effect. The processing of the immediate products is considered "stemming from", and expenditures by producers of the immediate products that stimulate other economic activities is the "induced by" effect (Ciriacy-Wantrup, 1955). An example of an induced, secondary net benefit would be the increased sale of supplemental feeds to livestock operators utilizing the AUMs gained from control minus the cost of producing the extra feed.

Under conditions of full employment, secondary net benefits do not exist from the national perspective taken in this study because only a regional transfer of productive resources is involved which does not increase national output (McKean, 1958). With fully employed resources, the extra factors of production drawn into a region by the increased production (stimulated by the increased AUMs in this case) are simply transferred from marginal uses elsewhere (McKean, 1958). This has distributional implications, but it is irrelevant as far as the economic feasibility of prairie dog control is concerned. Although the utilization of unemployed or underemployed resources would increase national output, McKean (1958) suggests that the assumption of full employment is generally made because of the difficulties involved in evaluating an individual project's effects on unemployment. Thus, under the assumption of full employment, no secondary net benefits are included in the economic analysis of prairie dog control.

Viewpoints

Two viewpoints were used to evaluate project costs and benefits based on who pays the costs and who receives the benefits. The viewpoints analyzed were those of the USFS (from a national perspective) and the ranchers involved.

The rancher viewpoint was basically prairie dog control conducted on private lands with no environmental considerations. It was assumed that ranchers conduct control on their own lands so that the EIS costs, black-footed ferret (Mustela frenata)[2] inventory and reconnaissance costs, and prairie dog towns left for black-footed ferret habitat were not included in this analysis. All added costs for environmental considerations were excluded and only the actual control costs were used. The USFS actual control costs were assumed to approximate the amount of money a group of ranchers would have to spend to contract out a large scale control operation.

The USFS viewpoint was separated into two analyses for evaluation. The first was the USFS acting as an agent of the sovereign.

[2]This ferret is an endangered species which relies on prairie dogs as its main food source.

Under this analysis, the USFS acts as an agent of society at large and accounts for all direct benefits and costs within a benefit-cost analysis (Nazir, 1972). The second analysis involved the USFS acting as a fiscal agent with their responsibility being only for the explicit benefits and costs of prairie dog control. While the costs of control are the same under both analyses, the dollar benefits gained are vastly different because the USFS as a fiscal agent accounts for only the revenue received directly by the agency and an agent of the sovereign accounts for all direct benefits without regard to whom they accure.

Method of control

The poisoning of prairie dogs was done with rolled oats laced with zinc phosphide. Untreated rolled oats were first pre-baited over an area to get prairie dog acceptance of the bait. Poisoned rolled oats were then distributed over the area one to three days after a successful pre-bait. Three-wheeled cycles were used as transportation between the prairie dog holes to distribute the oats. A straight line method was used for pre-baiting which covered only about half of the holes. With this method, cycles would travel in a relatively straight line pre-baiting only reasonably close holes. For the actual baiting itself, attempts were made to bait every prairie dog hole.

Control was done from the late summer (August or September) to the late fall (November or December) because of better prairie dog acceptance of the bait during this period and the lack of precipitation compared to other times of the year.

Both pre-treatment and post-treatment surveys were conducted on the control areas. Before any control was done, ferret reconnaissance surveys were done over the area to check for black-footed ferrets. Post-treatment surveys were conducted to assess the effect on non-target species and to gage the percentage of prairie dogs killed.

Benefits

The vegetation data collected by the Rocky Mountain Forest and Range Experiment Station from 1975 to 1979 were expressed in terms of standing crop production by species and sampled in June and August of each year (Table 2 lists the grazing treatments sampled). Utilization was measured only during the last two years of the sampling by clipping plots outside of the cages.

There are two distinct methods of measuring the effect prairie dogs have on vegetation production. One way compares vegetation production from outside prairie dog towns to that measured within dog towns. This method measures the changes due to prairie dog invasion. The other method compares vegetation production from areas where prairie dogs have been eliminated to vegetation production data from within a prairie dog town. This latter method was used in this study because it most accurately reflects the vegetation benefits that result from prairie dog elimination.

Ideally, the vegetation production data should reflect the influence of cattle grazing on both the prairie dog eliminated area and the prairie dog town area. Only no grazing exclosures were

Table 2. Areas sampled for vegetative production and utilization by species, 1975-1979.

	Years sampled				
Sampling areas	1975	1976	1977	1978	1979
Clipping under cages					
1. no grazing exclosures[a]	x	x	x	x	x
2. prairie dog grazing exclosures	x	x	x	x	x
3. cattle and prairie dog grazing	x	x	x	x	x
4. cattle grazing only[b]	x	x	x		
Clipping outside of cages					
5. no grazing exclosures				x	x
6. prairie dog grazing exclosures				x	x
7. cattle and prairie dog grazing				x	x

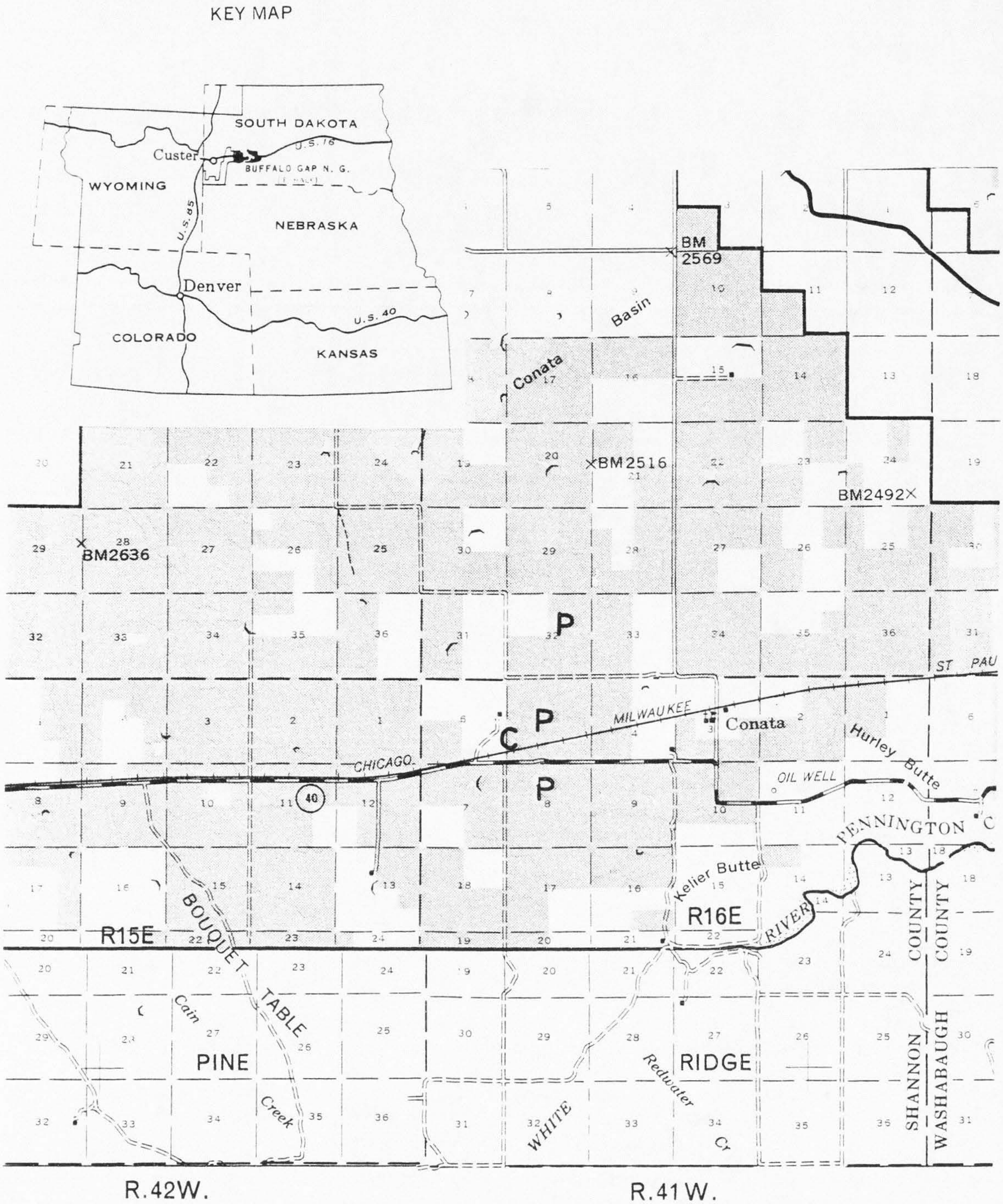
[a]The effect of the cage on a species' production was evaluated for each major cattle forage species. None of the species showed statistically significant differences between cage and outside cage production in the no grazing areas.

[b]This site was discontinued due to prairie dogs invading the area.

available to represent production on prairie dog eliminated areas In order to consistently eliminate cattle effects on both areas, prairie dog grazing exclosures were used as the comparable grazed prairie dog town areas. Thus, the no grazing exclosures represent the vegetation production with control and the prairie dog grazing exclosures represent vegetation production without control. The areas with cattle grazing only and those with cattle and prairie dog grazing reflect vegetation production before and after prairie dog invasion. These areas were used in the discussion section to evaluate the forage gained from preventing the spread of prairie dogs.

The vegetation data used in this study was collected on the Lower Sage Creek and Conata West grazing allotments of the Buffalo Gap National Grassland. Three no grazing exclosures and three prairie dog grazing exclosures were set up on prairie dog towns in these allotments. Figure 1 shows the location of these exclosures on the Conata basin. All exclosures were one acre in size, and those for no grazing were fenced to exclude both prairie dogs and cattle. Prairie dogs within these exclosures were poisoned. The prairie dog grazing exclosures were fenced to exclude only cattle.

Vegetation production data were in pounds per acre (lb/ac) and were sampled by clipping two square feet plots under moveable, eight by ten feet cages. Forty plots were clipped for all exclosures and sample sites (there were three for cattle and prairie dog grazing but only two for cattle grazing only) in 1976 and 1977. Ten plots were clipped at all exclosures and sample sites in 1975, 1978, and 1979 except for the no grazing exclosures which had only eight clipped



P: one no grazing exclosure, one prairie dog grazing exclosure, and one cattle and prairie dog grazing site located together
C: cattle grazing only sites

Figure 1. Location of the grazing treatment exclosures and sites on the east half of the Buffalo Gap National Grassland (shaded areas) in the Conata basin.

plots the last two years.

The analysis of the vegetation production data for changes due to prairie dog elimination was divided into two parts: 1) plant production changes due to elimination, and 2) changes in forage availability due to elimination of prairie dog utilization of plant species. Production changes in lb/ac were analyzed using the 4-year average production under cages in the no grazing exclosures minus the 4-year average production under cages on the prairie dog grazing exclosures. Only four years of data (1976 to 1979) were used to be consistent with the assumption that forage benefits begin the second grazing season after control (1975 being the initial year that prairie dog and cattle grazing were excluded in the no grazing exclosures). Prairie dog utilization for each plant species was measured as a weighted average over the last two years on prairie dog grazing exclosures. These utilization percentages were multiplied by the 4-year average production under cages on the prairie dog grazing exclosures to give the average lb/ac consumed by prairie dogs for each species over the 4-year period.

For the most part, August standing crop production data was used as the average for each species. The only exceptions were forbs (where the largest of June or August data was used) and cool-season grasses or grass-like plants. In the latter case, June production data was used if it was statistically greater (no overlapping confidence intervals) than August production data.

Data for both lb/ac of production changes and elimination of prairie dog utilization due to prairie dog control were multiplied by cattle utilization percentages to be converted into usable lb/ac of cattle forage. These cattle use percentages for each forage species were obtained from research done by Vavra et al. (1977) in northeastern Colorado.

In the final analysis, six categories of species that make up the majority of cattle forage in the area were evaluated for production changes and prairie dog utilization. Blue grama and buffalograss were lumped together because they were not separated during the first three years of data collection. Western wheatgrass and sun sedge (*Carex heliophila*) were evaluated separately, while the rest of the grasses found on the Conata basin were lumped together into a fourth category. Only two forbs, scarlet globemallow and black medick (*Medicago lupilina*), were regarded as abundant enough to categorize separately. No shrubs of any significance were found in the area.

The total change in usable cattle forage attributed to control was found by adding up the lb/ac of usable cattle forage from the production changes and prairie dog utilization for the six categories. This total change in lb/ac of usable cattle forage was divided into 800 pounds of usable forage required per AUM to give the acres of control needed to obtain one increased AUM of grazing. The forage gained was assumed to begin during the second grazing season after initial control (or retreatment in some areas) was done. So if control were done in the Fall of 1978, increased cattle forage would begin in 1980.

Two scenarios were used to determine the expected life of the prairie dog control project: one with a required annual maintenance program after major control efforts cease to prevent prairie dog re-invasion and the other without annual maintenance. In either scenario, the annual maintenance control acreage or the number of years for prairie dogs to completely re-invade the control area varied with the estimated population of prairie dogs left after major control efforts cease.

For the USFS viewpoint, between 4000 and 5000 acres (4500 acres was used in this study) of prairie dog towns were left on the Conata basin primarily for black-footed ferret habitat. The 30 percent annual growth rate in infested acres assumed for this population is a little below the very rapid expansion rates of the early 1970s (which were about 32 to 35 percent), but still above more normal rates of growth. This 30 percent annual growth rate is above more normal rates of growth because it also accounts for expansion of the remaining prairie dogs not killed during initial control or retreatment. Annual maintenance for this viewpoint was estimated to be 1350 (4500 x 0.3) acres beginning in 1981 (Table 3).

Table 3. Base populations of prairie dog infested acres assumed for the two viewpoints.

Viewpoint	Base population in acres	Assumed annual growth	Required annual maintenance acres
USFS	4500	30 percent	1350
Rancher	1200	30 percent	360

For the rancher viewpoint, it was assumed that these estimated 4500 acres of prairie dogs were controlled in 1981 and only those prairie dogs not killed during initial control or retreatment remained. The acres of prairie dog towns left was estimated to be 7 percent[3] of the 5850 (4500 + (4500 x 0.3)) acres assumed to be controlled in 1981 added to an assumed 3 percent of the prairie dog population surviving the initial control and retreatment on 29,168 acres from 1978 through 1980. The 3 percent figure is approximately half of the 7 percent prairie dogs missed by initial control and assumed to be left after retreatment of the controlled areas. This totals to approximately 1200[4] acres of prairie dogs from which 30 percent annual growth was assumed to occur. This is a higher than normal growth, but 360 acres of annual maintenance control provides a margin of error for the rough estimate of 1200 acres of prairie dogs.

In the scenarios without annual maintenance, the acres of prairie dogs eliminated by control were assumed to decrease because of annual 30 percent increases in prairie dog infested acres from the base populations of 4500 acres in the USFS viewpoint and 1200 acres in the rancher viewpoint.

The value of an AUM of grazing throughout the project life was the same for two of the analyses in this study. A private market value for an AUM was used in the rancher and the USFS as an agent of sovereign viewpoints. In the private market, an AUM of grazing was

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[3]Estimated control success on the Conata basin was 92 to 94 percent in 1978 and 1979.

[4]This figure is rounded down from a calculated 1285 acres ((5850 x 0.07) + (29,168 x 0.03)).

valued as the forage part of 1979 private lease rates for western South Dakota. The closest estimate to this is a per acre leasing arrangement because per acre leasors generally provide little or no services such as salting, fence maintenance, and herding according to a survey[5] in Wyoming by the Wyoming Crop and Livestock Reporting Service (1979). In 1979, the South Dakota Crop & Livestock Reporter estimated a $6 per acre cash rent for pastures (mostly rangeland) in the western part of South Dakota (USDA, 1979). Given that the carrying capacity of the Conata basin is about 2 acres per AUM in the summer, which is between moderate and heavy stocking for a mixed grass prairie according to Lewis et al. (1956), an AUM of grazing was worth $12 in 1979.

The entire value of the cattle forage gained from prairie dog control was regarded as the benefit for the USFS acting as an agent of the sovereign with the rationale being that the forage was made available even though its full value was not charged as a fee. Acting as a fiscal agent, though, only the 1979 National Grassland fee of $2.85 per AUM was used as the value of an AUM throughout the life of the project.

From the rancher viewpoint, it was assumed that prairie dog control was conducted on their own private land in the Conata basin. Thus, the benefit gained is the value of the forage in a private market lease that can be regarded as either the lease rate at which this forage could be leased to another rancher or a lease from another

[5] Only a per acre leasing arrangement provided few services. Leasing of forage on an AUM or on a weight gain basis did generally include services.

landowner that is avoided by undertaking prairie dog control.

Costs

The control costs accounted for include planning, management, actual control costs, and post-treatment monitoring costs. Generally, the cost figures used were the same as those provided by the USFS except for the three-wheeled cycles purchased as part of the control program which were amortized over a four year life at a 10 percent rate of interest. Also, black-footed ferret inventory, planning, and post-treatment monitoring costs accounted for in 1979, but not in 1978, were assigned the same per acre cost in 1978 as in 1979. These control costs were used in the USFS viewpoint while the rancher viewpoint included only the actual control costs with no ferret inventory, planning, or post-treatment monitoring costs considered.

The cost of the EIS done for the control program was estimated by James Lees of the Nebraska National Forest. The EIS costs were included in only the USFS viewpoint. Since the ranchers were assumed to have controlled prairie dogs on their own lands, it was assumed they did not prepare any EIS's.

Economic feasibility criteria

Both viewpoint use 1978 (the first year of control) as the base year for discounting all future benefits and costs. Only real (inflation free) costs and benefits were used in this study and were discounted with real discount rates. Discounting was done because a dollar in costs or benefits occurring in the future is worth less than a dollar paid out or received at present. The interest rate used to reduce future costs and benefits to their present value can be regarded as the opportunity cost of the money invested or the interest rate that must be paid on borrowed funds to finance the project. If both of these rates were known, the highest would be used, but often only one can be accurately estimated and must be used.

A 10 percent discount rate recommended by the Office of Management and Budget in 1978 was used for the USFS viewpoint. This rate is close to the real opportunity cost of government investments (the weighted average real rate of return in the private sector) found to be 10.4 percent by Stockfish (1969). This same 10 percent discount rate was used for the rancher viewpoint as the real opportunity cost of money invested because the 1978 interest rate charged to ranchers in South Dakota would account for inflation and not represent a real discount rate.

The two economic feasibility criteria used to compare benefits and costs were present net worth (PNW) and benefit-cost ratio (B/C ratio). PNW involves discounting all costs and benefits from future years back to 1978 and substracting the discounted costs from the discounted benefits. A positive value indicates a feasible project. A B/C ratio was found by dividing the discounted benefits by the sum of discounted costs and initial investment. A ratio equal to or greater than one indicates economic feasibility. The general equations (Gittinger, 1972) for these two criteria are:

$$\text{present net worth} = \sum_{t=0}^{n} \frac{B_n - C_n}{(1+i)^n}$$

$$\text{benefit-cost ratio} = \frac{\displaystyle\sum_{t=0}^{n} \frac{B_n}{(1+i)^n}}{\displaystyle\sum_{t=0}^{n} \frac{C_n}{(1+i)^n}}$$

where:

B_n = benefits in each year

C_n = costs in each year

n = number of years

i = discount rate

Sensitivity analyses were conducted which involved re-doing the analyses based on 95 percent confidence intervals of the yearly production figures for each cattle forage species in the no grazing and prairie dog grazing exclosures. These high and low confidence bounds were determined by the Stratified Random Sampling technique (Scheaffer, Mendenhall, and Ott, 1979).

The equation for the bound of error at the 95 percent confidence interval from this technique is:

$$1.96\sqrt{\frac{1}{N^2}\sum_{i=1}^{3} N_i^{\,2}\left[\frac{N_i - n_i}{N_i}\right]\left[\frac{S_i^{\,2}}{n_i}\right]}$$

where:

n_i = sample size for each population

N_i = size of each population

N = total of all sample populations

$S_i^{\,2}$ = each sample's variance

Each of the three one acre exclosures for no grazing and the three for prairie dog grazing were treated as sample populations. The variance (S^2) and sample size (n) for the vegetation production sampling on each exclosure were obtained from the experiment station data. With the size of each sample population being one acre, N_i would be 21,780 (43,560 square feet divided by two square feet for a clipped plot). N is three times 21,780 because three exclosures represent the total sample population for each grazing treatment.

A qualifying assumption had to be made for the other grasses category and for the last two years of data in the blue grama and buffalograss category that adding the variances of the component parts (a pooled variance[6]) approximates the variance of the sum total of these parts. So that when blue grama and buffalograss are sampled separately for vegetation production, adding their variances together will approximate the variance of a combined blue grama and buffalograss sample. Based on generated numbers, a pooled variance should be a close approximation (roughly within 10 percent) of a combined sample's variance once the square root is taken and divided by the square root of the sample size as in the equation.

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[6]See chapter 4 in Snedecor and Cochran (1967) for the method.

RESULTS

The estimated cattle forage benefits of prairie dog control are shown in Table 4. These estimates are based on the 4-year average productions from three one acre exclosures of no grazing and three prairie dog grazing exclosures. The average production and utilization computations for each cattle forage species category are found in the appendix (Tables 23 through 28).

As an example from Table 4, there is a production decline for western wheatgrass because the 4-year average production is 10 lb/ac greater on the prairie dog grazing exclosures compared to the no grazing exclosures. When multiplied by 0.6 for a cattle use percentage, usable cattle forage is reduced by 6 lb/ac in production with prairie dog control. This basically shows that no increase in western wheatgrass production occurs over a 5-year period due to control. For the elimination of prairie dog utilization, the 4-year average production on prairie dog grazing exclosures (52 lb/ac) is multiplied times the weighted average of the 1978 and 1979 prairie dog utilization percentages for western wheatgrass (0.41) to give 21 lb/ac gained from control. This amounts to 13 lb/ac of usable cattle forage. The total effect of prairie dog control on western wheatgrass, then, is an increase of 7 lb/ac of usable cattle forage (13 - 6).

The prairie dog utilization figures for blue grama and buffalograss and other grasses categories are from the August data only while the utilization figures for the other forage species categories are the highest of the June or August data. The cattle utilization

Table 4. Estimated amount of usable cattle forage resulting from prairie dog control on the Conata basin.

Category	Change in Herbage Production: no grazing minus prairie dog grazing	Herbage Production: prairie dog grazing	prairie dog use	cattle use		total usable cattle forage (lb/ac)
	— pounds per acre —					
Blue grama and Buffalograss						
production	(377-444)=-67			x 0.4	=	-27
prairie dog use		444	x 0.09	x 0.4	=	16
Western wheatgrass						
production	(42-52)=-10			x 0.6	=	-6
prairie dog use		52	x 0.41	x 0.6	=	13
Sun sedge						
production	(180-67)=113			x 0.6	=	68
prairie dog use		67	x 0.39	x 0.6	=	16
Other grasses						
production	(146-148)=-2			x 0.3	=	-1
prairie dog use		148	x 0.48	x 0.3	=	21
Scarlet globemallow						
production	(44-91)=-47			x 0.7	=	-33
prairie dog use		91	x 0.11	x 0.7	=	7
Black medick						
production	(32-48)=-16			x 0.5	=	-8
prairie dog use		48	x 0.70	x 0.5	=	18
						84

$$\frac{\text{800 pounds per AUM}}{\text{84 pounds per acre}} = \text{9.5 acres of control per AUM}$$

figures are conservative approximations from Vavra et al. (1977), though the utilization figure for the blue grama and buffalograss category was adjusted upward to account for heavy use of blue grama in September as observed by Reppert (1960) on shortgrass prairie. This was done because the research by Vavra et al. included June through August only while seasonal grazing on the Conata basin continues into early October. A conservative estimate of 30 percent utilization was made for the combination of all the grasses lumped into the other grasses category, and black medick was estimated to have 50 percent utilization by cattle.

One item of note from Table 4 is that sun sedge is the only cattle forage species that increases in production under the exclusion from prairie dog grazing. It accounts for an increase of 84 lb/ac in usable cattle forage while all the other forage categories total up to a zero increase in usable forage. By dividing the assumed 800 pounds of usable cattle forage per AUM by the 84 pounds of cattle forage gained per acre, it takes 9.5 acres of prairie dog control to gain one AUM of cattle grazing.

Table 5 shows the acres of initial prairie dog control and retreatment under both viewpoints and their scenarios. The 1978 through 1980 control acreages are those accomplished by the USFS. The acres controlled in 1981 are those assumed for each viewpoint.

The projected growth in the prairie dog population of infested acres under both no maintenance scenarios is listed in Table 6. The projected growth starts two years later for the USFS viewpoint to allow the full benefits of prairie dog control to come into effect before they are gradually eliminated by prairie dog re-invasion.

Table 5. Actual (1978-1980) and assumed (1981) acres of prairie dog control under both viewpoints.

Year	USFS with maintenance	USFS without maintenance	Rancher with maintenance	Rancher without maintenance
	acres			
1978				
initial control	5360	5360	5360	5360
retreatment[a]	0	0	0	0
1979				
initial control	18,060	18,060	18,060	18,060
retreatment[a]	2824	2824	2824	2824
1980				
initial control	5748	5748	5748	5748
retreatment[a]	3505	3505	3505	3505
1981				
initial control	0	0	4500	4500
retreatment[a]	1350	1350	1350	1350

[a]The retreatment of areas is done because of prairie dog town expansion and to mop up areas where more than a few prairie dogs were missed during the previous year.

Table 6. Projected growth in prairie dog infested acres at the assumed 30 percent annual growth rate from base populations, no maintainence.

Year	USFS Viewpoint acres	USFS Viewpoint growth	Rancher Viewpoint acres	Rancher Viewpoint growth
1981	4500		1200	
		0		360
1982	4500		1560	
		0		468
1983	4500		2028	
		1350		608
1984	5850		2636	
		1855		781
1985	7605		3427	
		2185		1029
1986	9890		4456	
		2960		1336
1987	12,850		5792	
		3860		1738
1988	16,710		7530	
		5010		2260
1989	21,720		9790	
		6520		2935
1990	28,240		12,725	
		8470		3818
1991	36,710		16,543	
				4952
1992			21,505	
				6455
1993			27,960	
				8385
1994			36,345	

This optimistic assumption was made to simplify the scenario by separating the increases in acres with increased cattle forage due to elimination of prairie dogs from the declines caused by prairie dog re-invasion.

The resulting AUMs gained from prairie dog control for the USFS viewpoint are presented in Table 7 and those for the rancher viewpoint are in Table 8. Increased AUMs from the acres with increased cattle forage (84 lb/ac) are assumed to start two years after the year of initial control or retreatment. Thus, the 5360 acres controlled in 1978 minus the 2824 acres retreated in 1979 (Table 5) mean that 2536 acres are first counted in 1980 as increasing AUMs. The 1981 acres with increased cattle forage include:

2536 acres	in 1980
+2824 acres	retreated in 1979
+14,555 acres	initially controlled in 1979 and not retreated in 1980
19,915 acres	

To account for 3 percent of the prairie dog population assumed to remain after initial control and retreatment in the USFS viewpoint, the maximum acreage in Table 7 with and without maintenance was reduced by 3 percent. Thus, instead of 29,168 acres in 1983 (the total acreage of prairie dog control with a 100 percent kill) under the no maintenance scenario, the figure used is 28,300 acres. To be consistent, the acres with increased cattle forage in 1982 were reduced by 3 percent in both USFS scenarios even though it is not the maximum figure for the no maintenance scenario. So in 1982, the acres with increased cattle forage for the USFS viewpoint include:

Table 7. Acres with increased cattle forage from prairie dog elimination and the AUMs gained for the USFS viewpoint with and without maintenance.

	With Maintenance		Without Maintenance	
Year	acres	AUMs (acres/9.5)	acres	AUMs (acres/9.5)
1979	0	0	0	0
1980	2536	267	2536	267
1981	19,915	2096	19,915	2096
1982	27,000	2842	27,000	2842
1983	"	"	28,300	2978
1984	"	"	26,950	2837
1985	"	"	25,095	2642
1986	"	"	22,910	2412
1987	"	"	19,950	2100
1988	"	"	16,090	1694
1989	"	"	11,080	1166
1990	"	"	4560	480
1991	"	"	0	0
	(continues until 2012)			

Table 8. Acres with increased cattle forage from prairie dog elimination and the AUMs gained for the rancher viewpoint with and without maintenance.

Year	With Maintenance acres	With Maintenance AUMs (acres/9.5)	Without Maintenance acres	Without Maintenance AUMs (acres/9.5)
1979	0	0	0	0
1980	2536	267	2536	267
1981	19,915	2096	19,915	2096
1982	27.818	2928	27,818	2928
1983	32,108	3380	32,108	3380
1984	"	"	31,640	3331
1985	"	"	31,032	3267
1986	"	"	30,251	3184
1987	"	"	29,222	3076
1988	"	"	27,886	2935
1989	"	"	26,148	2752
1990	"	"	23,888	2515
1991	"	"	20,953	2206
1992	"	"	17,135	1804
1993	"	"	12,183	1282
1994	"	"	5728	603
1995	"	"	0	0

(continues until 2013)

19,915 acres	in 1981
+3505 acres	retreated in 1980
+4398 acres	initially controlled in 1980 and not retreated in 1981
-818 acres	to account for the 3 percent prairie dogs
27,000 acres	

For the rancher viewpoint, this 3 percent population is accounted for by subtraction of the 1200 acres of remaining prairie dogs (plus 30 percent growth) from the maximum acreage (33,668 acres) which occurs in 1983.

The retreatment of 360 acres per year begins in 1982 for the maintenance scenario from the rancher viewpoint while the annual maintenance of 1350 acres for the USFS viewpoint begins in 1981. A projected life of 30 years is assumed for each starting the year after maintenance begins. This project life is just an estimate of a possible long term commitment to maintaining a large scale control program such as this.

The no maintenance scenario in Table 7 assumed that 1350 acres are retreated in 1981 and that this ends the prairie dog control program (Table 5). The full acres with increased cattle forage are allowed to come into effect in 1983 before the growth in infested acres of prairie dogs gradually eliminates the AUMs gained until they become zero in 1991. For example, prairie dog infested acres grows by 1350 acres between 1983 and 1984 (Table 6) and this decreases the acres in Table 7 from 28,300 to 26,950. Both scenarios from the rancher viewpoint assumed that 5850 acres are controlled in 1981, but this was assumed to end the control program for the no maintenance scenario with the projected prairie dog population growth finally eliminating the AUMs gained in 1995.

The yearly costs of the USFS control program are shown in Table 9. The amortization of the 11 three-wheeled cylces purchased by the USFS (six in 1978 and five in 1979) is shown in Table 10. Amortization is based on the premise that one is indifferent between paying \$825 in year one for a cycle or \$260 per year over their four year life. This was the only change in the cost figures supplied by the USFS aside from the ferret monitoring cost estimate included in 1978 (the 1979 cost of 66¢ per acre). The rancher viewpoint's per acre control costs do not include the added ferret reconnaissance, inventory, and planning costs. The 1981 prairie dog control costs and all future maintenance control costs were estimated to be \$5 per acre for the rancher viewpoint and \$5.50 per acre for the USFS viewpoint based on approximations of the 1980 cost figures. Thus, these costs are represented in real terms on the basis of the latest cost figures. The EIS was estimated by Lees (1980) to cost \$15,296 in 1977. A complete accounting of his estimate appears in the appendix (Table 29).

Tables 11 through 13 list the yearly, undiscounted benefits and costs for each viewpoint and their maintenance scenarios. The benefits are the value of an AUM multiplied times the AUMs gained from prairie dog control for each viewpoint. For example, the rancher has 1982 benefits of \$35,136 which is \$12 per AUM times 2928 AUMs (Table 8). The costs were calculated by the acres of control (Table 5) multiplied by the control cost per acre (Table 9). As an example, the 1980 costs for the rancher were 13,353 acres (initial control plus retreatment) times \$4.91 per acre which equals \$45,432.

The PNW and B/C ratio analyzed for each viewpoint scenario through the discounting process are also listed in Tables 11 through

Table 9. Actual USFS prairie dog control program costs through 1980 (Lees, 1980).

Category	1978	1979	1980
	dollars		
Equipment and Supplies (includes amortized cycles)	7302	16,605	17,729
Vehicle Expense	1957	4367	2706
Food Services	2795	6283	3166
Lodging	1575	6650	1127
Salaries			
Regular	8390	33,289	28,077
Premium	3439	6106	6006
Per Diem	896	1748	504
Young Adult Conservation Corp (YACC) expenses (crew salaries)	8814	24,200	9580
Total Project Costs	35,168	99,248	66,895[a]
Control Costs per Acre (Not including ferret reconnaissance)	6.56	4.75	4.91
Control Costs per Acre (includes ferret reconnaissance, inventory and planning)	7.22[b]	5.41	5.38

[a]Includes 3622 acres of control outside of the Conata basin and 725 acres of density control which were not considered in this study.

[b]Includes an estimate of the additional cost of ferret reconnaissance, inventory, and planning.

Table 10. Amortization[b] of the three-wheeled cycles purchased by the USFS.

Data needed to amortize	Information used
purchase price	\$825 per cycle
projected life of the cycle	4 years
discount rate	10 percent

Equation	Symbols and their meaning
$V_o = R \times \frac{(1 - (1+i)^{-n})}{i}$	V_o = the initial cost (\$825)
	R = the payment per year
	$\frac{(1 - (1+i)^{-n})}{i}$ = the discounting factor for the years one through four at a 10 percent discount rate (3.170)

Solution

$$\$825 = R \times 3.170$$

$$R = \frac{\$825}{3.170} = \$260 \text{ per year}$$

Year	Number of cycles		Cost per cycle		Yearly cost
1978	6	x	\$260	=	\$1560
1979	11	x	"	=	\$2860
1980	11	x	"	=	\$2860

[b]See chapter 17 in Bolton (1976) for a detailed explanation of this technique.

Table 11. The undiscounted costs and benefits, present net worth, and benefit-cost ratio of prairie dog control in the Conata basin for the rancher viewpoint with and without maintenance (one AUM valued at $12).

	With Maintenance		Without Maintenance	
Year	benefits	costs	benefits	costs
	dollars			
1978	0	35,162	0	35,162
1979	0	99,200	0	99,200
1980	3204	45,432	3204	45,432
1981	25,152	29,250	25,152	29,250
1982	35,136	1800	35,136	0
1983	40,560	"	40,560	"
1984	"	"	39,966	"
1985	"	"	39,198	"
1986	"	"	38,212	"
1987	"	"	36,912	"
1988	"	"	35,224	"
1989	"	"	33,029	"
1990	"	"	30,174	"
1991	"	"	26,467	"
1992	"	"	21,644	"
1993	"	"	15,389	"
1994	"	"	7235	"
1995	"	"	0	"
	(continues until 2013)			

Scenario	Present Net Worth	Benefit-Cost Ratio
With Maintenance	$109,011	$\frac{\$306,697}{\$197,686} = 1.55$
Without Maintenance	$17,806	$\frac{\$202,672}{\$184,866} = 1.10$

Table 12. The undiscounted costs and benefits, present net worth, and benefit-cost ratio of prairie dog control for the USFS acting as an agent of the sovereign with and without maintenance (one AUM valued at $12).

Year	With Maintenance benefits	With Maintenance costs	Without Maintenance benefits	Without Maintenance costs
	dollars			
1977	0	15,296	0	15,296
1978	0	38,699	0	38,699
1979	0	112,690	0	112,690
1980	3204	53,682	3204	53,682
1981	25,152	7425	25,152	7425
1982	34,104	"	34,104	0
1983	"	"	35,736	"
1984	"	"	34,044	"
1985	"	"	31,704	"
1986	"	"	28,944	"
1987	"	"	25,200	"
1988	"	"	20,328	"
1989	"	"	13,992	"
1990	"	"	5760	"
	(continues until 2012)			

Scenario	Present Net Worth	Benefit-Cost Ratio
With Maintenance	$ 2587	$\frac{\$263,381}{\$260,794} = 1.01$
Without Maintenance	-$66,634	$\frac{\$141,279}{\$207,913} = 0.68$

Table 13. The undiscounted costs and benefits, present net worth, and benefit-cost ratio of prairie dog control for the USFS acting as a fiscal agent viewpoint with and without maintenance (one AUM valued at $2.85).

	With Maintenance		Without Maintenance	
Year	benefits	costs	benefits	costs
	dollars			
1977	0	15,296	0	15,296
1978	0	38,699	0	38,699
1979	0	112,690	0	112,690
1980	761	53,682	761	53,682
1981	5974	7425	5974	7425
1982	8100	"	8100	0
1983	"	"	8487	"
1984	"	"	8085	"
1985	"	"	7530	"
1986	"	"	6874	"
1987	"	"	5985	"
1988	"	"	4828	"
1989	"	"	3323	"
1990	"	"	1368	"
	(continues until 2012)			

Scenario	Present Net Worth	Benefit-Cost Ratio
With Maintenance	-$198,016	$\frac{\$62,778}{\$260,794} = 0.24$
Without Maintenance	-$174,360	$\frac{\$33,553}{\$207,913} = 0.16$

13. The calculations of the PNW and B/C ratio of prairie dog control for the rancher viewpoint with maintenance are:

$$\text{PNW} = -\$35{,}162 + \frac{-\$99{,}200}{1+0.1} + \frac{(\$3204-\$45{,}432)}{(1+0.1)^2} + \frac{(\$25{,}152-\$29{,}250)}{(1+0.1)^3} +$$

$$\frac{(\$35{,}136-\$1800)}{(1+0.1)^4} + \frac{(\$40{,}560-\$1800)}{(1+0.1)^5} + \cdots + \frac{(\$40{,}560-\$1800)}{(1+0.1)^{34}}$$

$$\text{PNW} = \$109{,}011$$

$$\text{B/C ratio} = \frac{\dfrac{\$3204}{(1+0.1)^2} + \dfrac{\$25{,}152}{(1+0.1)^3} + \dfrac{\$35{,}136}{(1+0.1)^4} + \dfrac{\$40{,}560}{(1+0.1)^5} + \cdots +}{\$35{,}162 + \dfrac{\$99{,}200}{1+0.1} + \dfrac{\$45{,}432}{(1+0.1)^2} + \dfrac{\$29{,}250}{(1+0.1)^3} + \dfrac{\$1800}{(1+0.1)^4} +}$$

$$\frac{\dfrac{\$40{,}560}{(1+0.1)^{34}}}{\cdots + \dfrac{\$1800}{(1+0.1)^{34}}} = \frac{\$306{,}697}{\$197{,}686} = 1.55$$

Prairie dog control is economically feasible both with and without maintenance for the rancher viewpoint (Table 11), but only the with maintenance scenario is feasible for the USFS acting as a sovereign agent (Table 12). For the analysis of the USFS acting as a fiscal agent, prairie dog control is not economically feasible (Table 13).

The agent of the sovereign is the most appropriate analysis for an USFS economic evaluation of prairie dog control because the entire value of an AUM gained from control ($12) is accounted for in the analysis. The fiscal agent analysis represents a cash-flow analysis which does not account for the full value of an AUM, only the USFS grazing fee. Generally, federal agencies are regarded as agents of the sovereign in economic analyses of their programs rather than as fiscal agents which better represents private firms.

In order to calculate a confidence interval within which the true estimate of economic feasibility lies, production confidence intervals over the 4-year period for each forage species category were generated (Table 14). The yearly confidence intervals for each category are listed in appendix Tables 30 and 31 along with the variances for each exclosure needed for computation. The 4-year production bounds listed in Table 14 are averages of the bounds of error (1976 to 1979) for each forage species category from Tables 30 and 31.

The same method described above for computing the lb/ac of usable cattle forage gained from prairie dog control was used to calculate the low and high bounds of usable cattle forage gained from control. With the same prairie dog utilization percentages assumed for each bound, the results from Table 15 show 56 lb/ac for the low bound and 112 lb/ac for the high bound. As an example, western wheatgrass production in the low bound was 14 (42-28) lb/ac in the no grazing exclosures compared to 30 (52-22) lb/ac in the prairie dog grazing exclosures. This is a decline of 16 lb/ac for a production change. The 30 lb/ac was multiplied by 0.41 to estimate the amount of western wheatgrass utilized by prairie dogs. Acres of control needed to gain an AUM were 14.3 for the low bound and 7.1 for the high bound. The same acres with increased cattle forage, values per AUM, and costs of control were used to find the PNW and B/C ratio confidence intervals in Table 16.

Table 14. The four year average standing crop production for the six cattle forage species categories and their 95 percent confidence bounds.

	No Grazing Exclosures		Prairie Dog Grazing Exclosures	
Category	average	bounds	average	bounds
	pounds per acre			
Western wheatgrass	42	± 28	52	± 22
Blue grama and Buffalograss	377	± 68	444	± 91
Sun sedge	180	± 27	67	± 14
Other grasses	146	± 79	148	± 78
Scarlet globemallow	44	± 14	91	± 30
Black medick	32	± 34	48	± 49

Table 15. Calculation of the low and high bounds of cattle forage increased by prairie dog control, 95 percent confidence interval.

-Low Bound-

Category	Change in Herbage Production: no grazing minus prairie dog grazing	Herbage Production: prairie dog grazing	prairie dog use	cattle use		total usable cattle forage (lb/ac)
	—— pounds per acre ——					
Blue grama and Buffalograss						
production	(309-353)=-44			x 0.4	=	-18
prairie dog use		353	x 0.09	x 0.4	=	13
Western wheatgrass						
production	(14-30)=-16			x 0.6	=	-10
prairie dog use		30	x 0.41	x 0.6	=	7
Sun sedge						
production	(153-53)=100			x 0.6	=	60
prairie dog use		53	x 0.39	x 0.6	=	12
Other grasses						
production	(69-70)=-1			x 0.3	=	0
prairie dog use		70	x 0.48	x 0.3	=	10
Scarlet globemallow						
production	(30-61)=-31			x 0.7	=	-23
prairie dog use		61	x 0.11	x 0.7	=	5
Black medick						
production	(0-0)=0			x 0.5	=	0
prairie dog use		0	x 0.70	x 0.5	=	0
						56

$$\frac{\text{800 pounds per AUM}}{\text{56 pounds per acre}} = \text{14.3 acres of control per AUM}$$

Table 15. Continued

-High Bound-

Category	Change in Herbage Production: no grazing minus prairie dog grazing	Herbage Production: prairie dog grazing	prairie dog use	cattle use		total usable cattle forage (lb/ac)
	—— pounds per acre ——					
Blue grama and Buffalograss						
production	(445-535)=-90			x 0.4	=	-36
prairie dog use		535	x 0.09	x 0.4	=	19
Western wheatgrass						
production	(70-74)=-4			x 0.6	=	-2
prairie dog use		74	x 0.41	x 0.6	=	18
Sun sedge						
production	(207-81)=126			x 0.6	=	76
prairie dog use		81	x 0.39	x 0.6	=	19
Other grasses						
production	(225-226)=-1			x 0.3	=	0
prairie dog use		226	x 0.48	x 0.3	=	33
Scarlet globemallow						
production	(58-121)=-63			x 0.7	=	-44
prairie dog use		121	x 0.11	x 0.7	=	9
Black medick						
production	(66-97)=-31			x 0.5	=	-16
prairie dog use		97	x 0.70	x 0.5	=	36
						112

$$\frac{\text{800 pounds per AUM}}{\text{112 pounds per acre}} = \text{7.1 acres of control per AUM}$$

Table 16. The present net worth and benefit-cost ratio bounds, 95 percent confidence intervals, for the economic feasibility of prairie dog control.

	Present Net Worth			Benefit-Cost Ratio		
Viewpoints	high	average	low	high	average	low
	- thousands of dollars -					
Rancher						
with maintenance	213	109	6	2.08	1.55	1.03
without maintenance	83	18	-52	1.45	1.10	0.72
USFS as an agent of the sovereign						
with maintenance	92	3	-86	1.35	1.01	0.67
without maintenance	-18	-66	-114	0.91	0.68	0.45
USFS as a fiscal agent						
with maintenance	-176	-198	-218	0.32	0.24	0.16
without maintenance	-163	-174	-185	0.22	0.16	0.11

Lastly, the equations in Table 17 were generated to find the maximum breakeven cost of prairie dog control per acre given a value of an AUM. These equations were derived by taking the summation of the annual AUMs gained from control in Table 7 or 8, each multiplied by a discount factor and a constant value per AUM (X), and setting this equal to the summation of the annual acres of actual and assumed control and retreatment from each viewpoint (Table 5), each multiplied by a discount factor and a constant control cost per acre (Y). An example of this calculation is shown in Table 18. For the USFS viewpoint, the 16,826 is the cost of the EIS compounded forward to 1978. Figures 2 through 5 are graphed from the numbers (Table 19) generated from these equations along with the 95 percent confidence intervals on each (these equations are in the appendix, Table 32). The numbers in Table 19 were generated by plugging a value for an AUM into X in the equations and calculating the maximum breakeven cost per acre (Y).

With the AUM value of $12 used in this study, the rancher control costs of under $5 per acre the last two years of control are well below the maximum breakeven treatment costs per acre with or without maintenance in Table 19. The USFS control costs of about $5.40 per acre over the last two years are under the with maintenance breakeven cost of $5.80 per acre, but well above the $3.77 maximum cost for no maintenance.

Figures 2 through 5 show a range of control costs per acre within which prairie dog control will likely be feasible for given AUM values. The assumptions of these graphs are: 1) that the area of control is similar to the Conata basin so that the vegetative response

Table 17. Equations used to find the maximum breakeven prairie dog control cost per acre (Y) given a dollar value per AUM (X) for each viewpoint with and without maintenance.

Viewpoint	With Maintenance	Without Maintenance
USFS	$Y = \dfrac{22,036X - 16,826}{42,622}$	$Y = \dfrac{11,773X - 16,826}{33,007}$
	$Y = 0.517X - 0.40$	$Y = 0.357X - 0.51$
Rancher	$Y = \dfrac{25,682X}{38,963}$	$Y = \dfrac{16,691X}{36,386}$
	$Y = 0.659X$	$Y = 0.459X$

Table 18. Calculation of the maximum breakeven treatment cost per acre for the rancher viewpoint under the no maintenance scenario.

	Benefits				Costs		
Year	discount factor[a]	AUMs	value of an AUM	value per year	acres	treatment costs per acre	value per year
1978	1.0000	0	X	0	5360	Y	5360Y
1979	0.9091	0	"	0	20,884	"	18,986Y
1980	0.8264	267	"	221X	9253	"	7647Y
1981	0.7513	2096	"	1575X	5850	"	4393Y
1982	0.6830	2928	"	2000X			36,386Y
1983	0.6209	3380	"	2099X			
1984	0.5645	3331	"	1880X			
1985	0.5132	3267	"	1677X			
1986	0.4665	3184	"	1485X			
1987	0.4241	3076	"	1305X			
1988	0.3855	2935	"	1131X			
1989	0.3505	2752	"	965X			
1990	0.3186	2515	"	801X			
1991	0.2897	2206	"	639X			
1992	0.2633	1804	"	475X			
1993	0.2394	1282	"	307X			
1994	0.2176	603	"	131X			
				16,691X			

[a]A 10 percent discount rate was used.

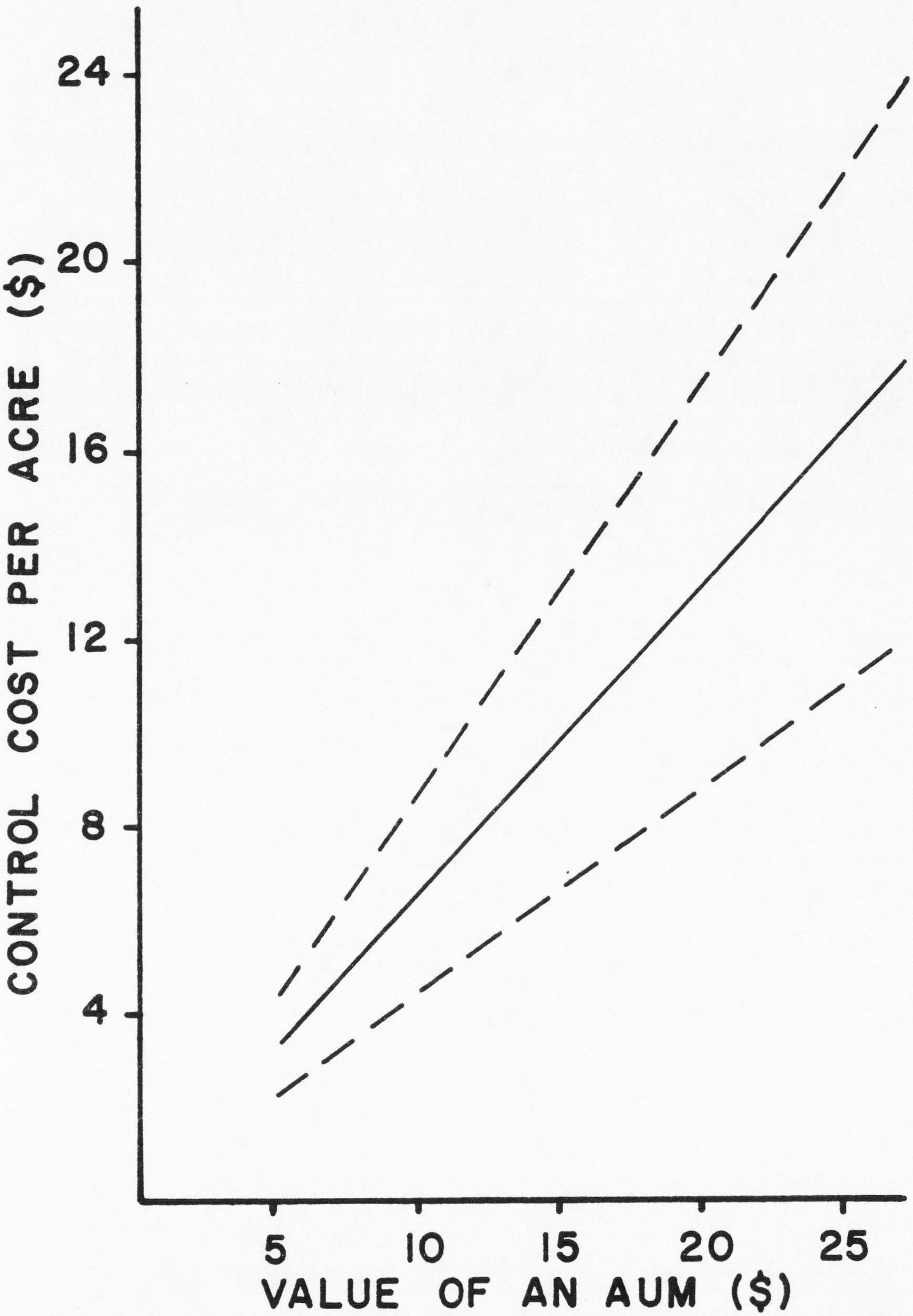

Figure 2. Maximum breakeven treatment costs per acre by ranchers with 95 percent confidence bounds, with maintenance.

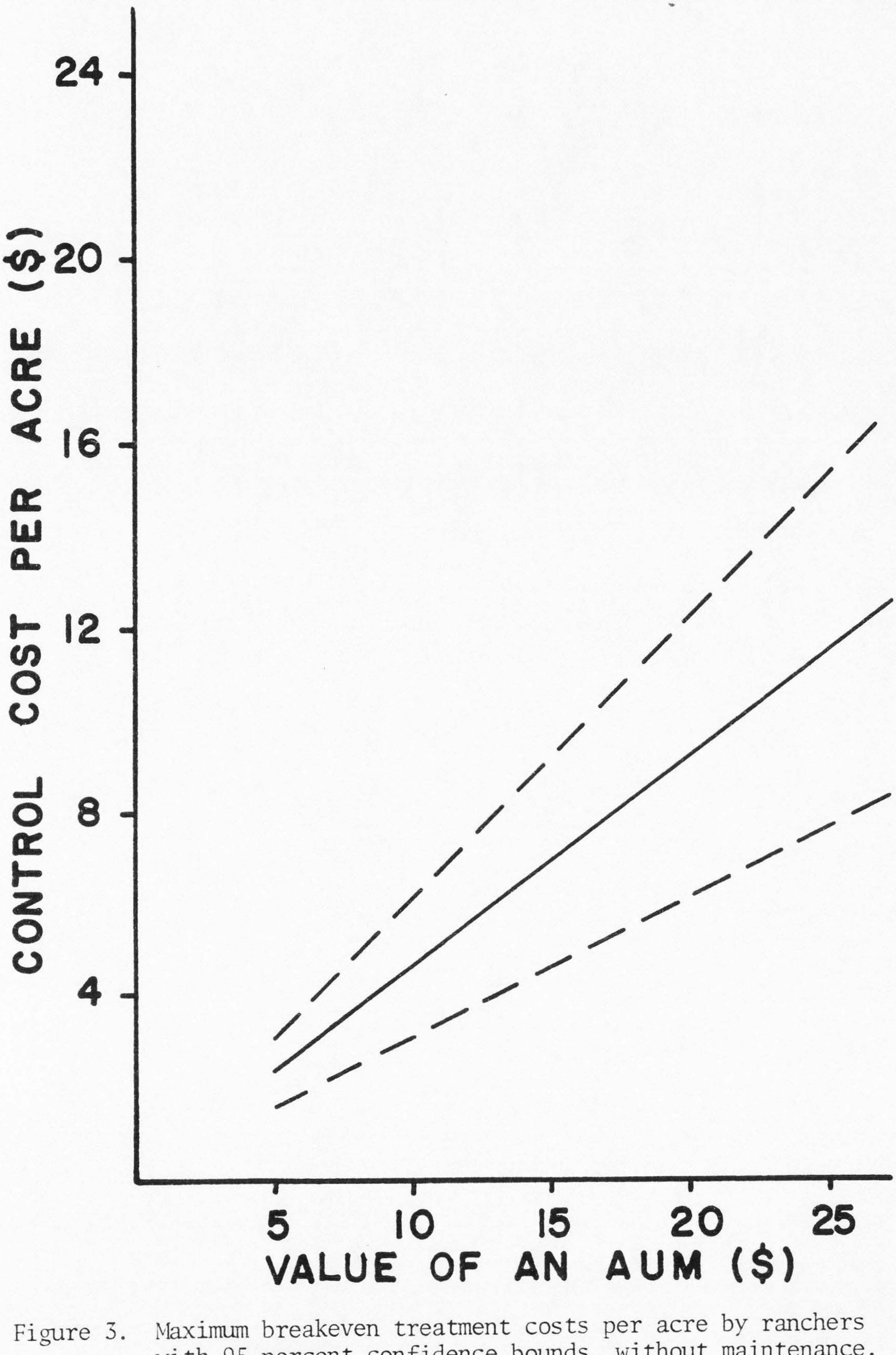

Figure 3. Maximum breakeven treatment costs per acre by ranchers with 95 percent confidence bounds, without maintenance.

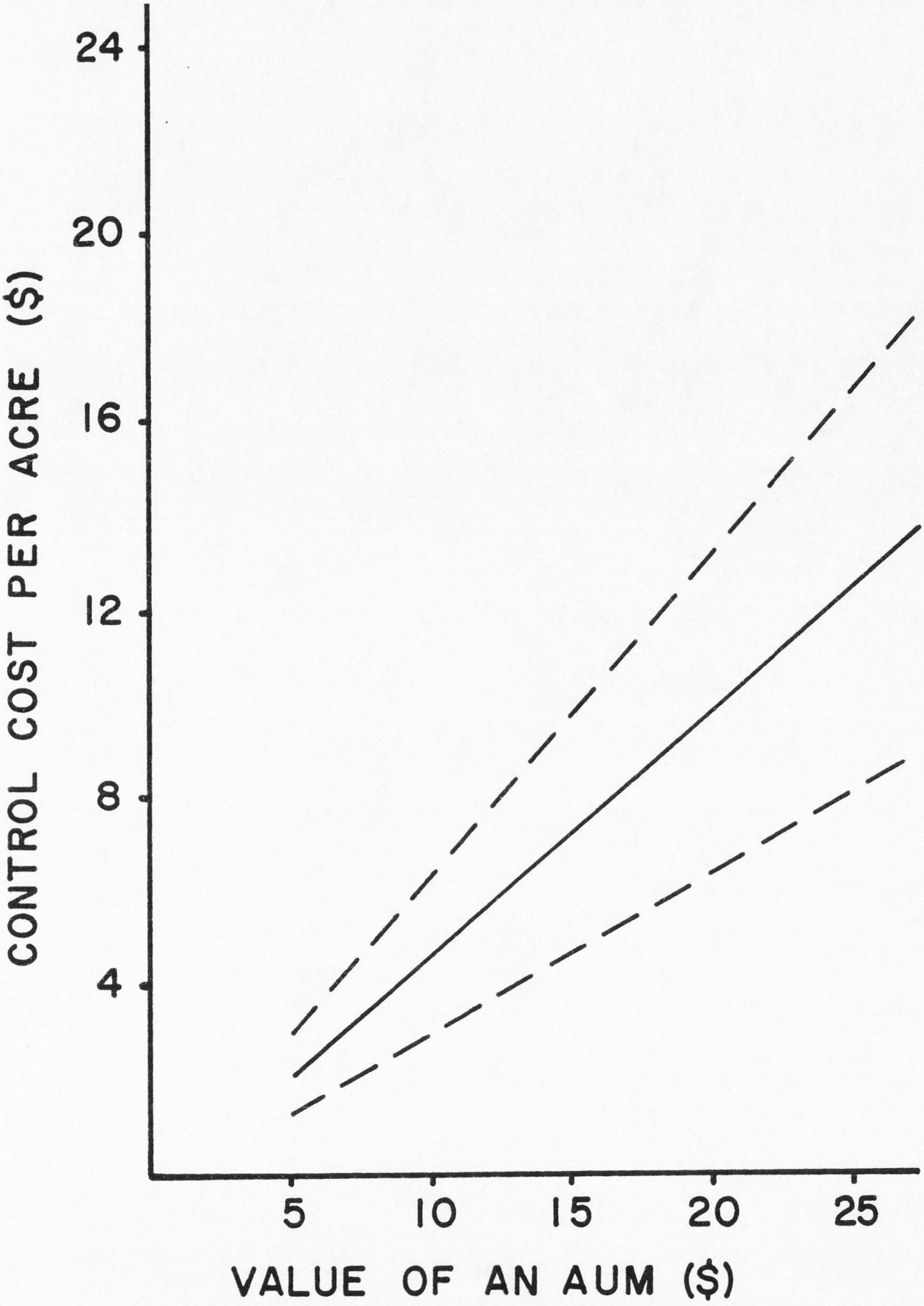

Figure 4. Maximum breakeven treatment costs per acre with 95 percent confidence bounds for the USFS viewpoint, with maintenance.

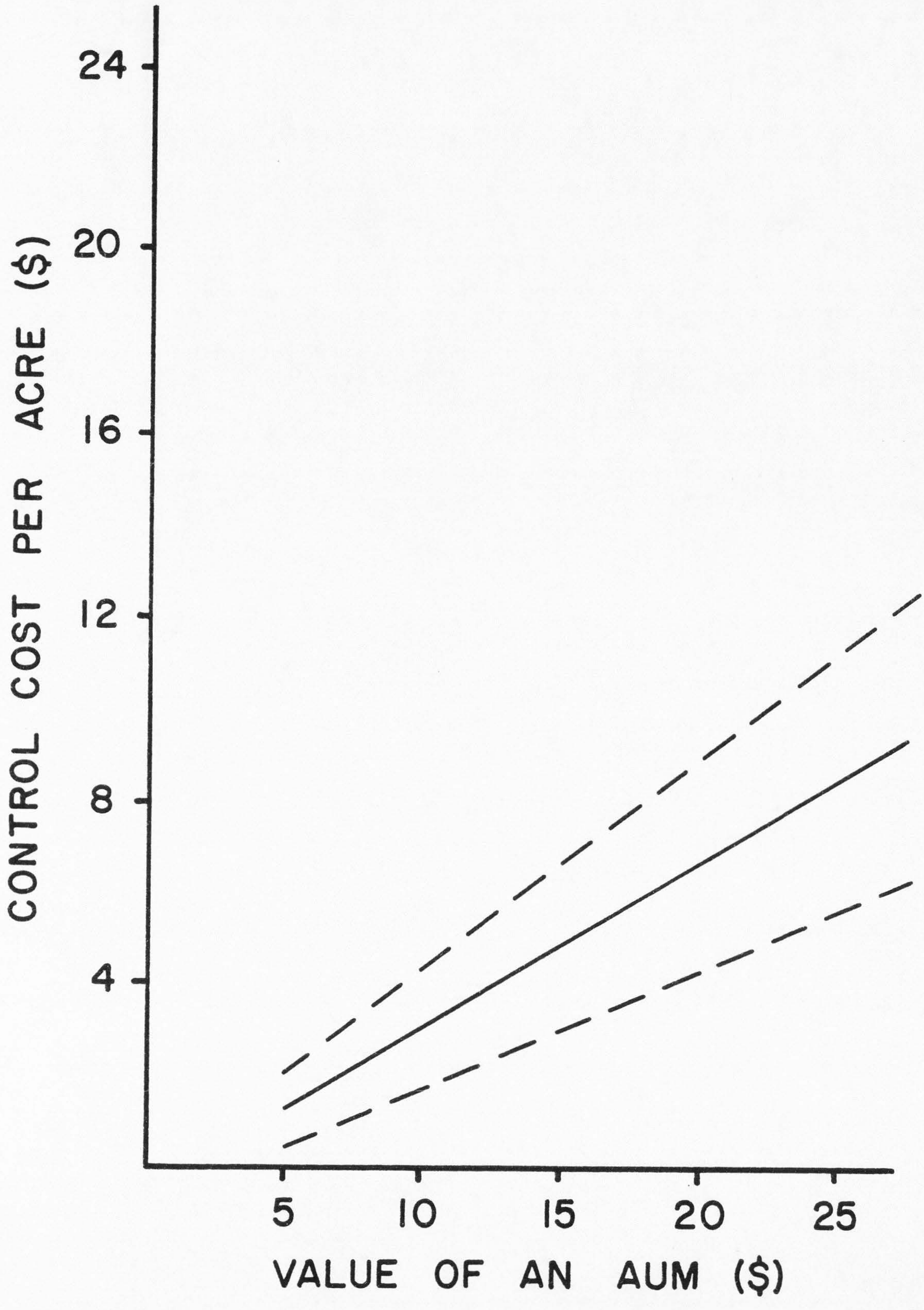

Figure 5. Maximum breakeven treatment costs per acre with 95 percent confidence bounds for the USFS viewpoint, without maintenance.

Table 19. Breakeven prairie dog control costs per acre in the Conata basin for given AUM values.

Value of an AUM	USFS with maintenance	USFS without maintenance	Rancher with maintenance	Rancher without maintenance
	dollars			
5	2.19	1.28	3.30	2.30
10	4.77	3.06	6.59	4.59
12	5.80	3.77	7.91	5.51
15	7.36	4.85	9.89	6.89
20	9.94	6.63	13.18	9.18
25	12.53	8.42	16.48	11.48
27	13.56	9.13	17.79	12.39

is about the same, 2) that the cost of control is relatively constant over the control program, 3) that the same discount rate is used, 4) that the success of kill is the same as in this program, and 5) that prairie dog expansion is approximately the same rate as in the Conata basin and that a maintenance program of the same relative size is included in the control program.

DISCUSSION

The dramatic difference between the PNWs for both rancher scenarios (Table 11) and those of the USFS acting as an agent of the sovereign (Table 12) illustrates the effect environmental considerations have on the economic feasibility of prairie dog control. Environmental considerations add to the costs of prairie dog control explicitly (black-footed ferret surveys) and implicitly (higher maintenance acres or a faster prairie dog population recovery period after control). While control from the viewpoint of the USFS as a sovereign agent is feasible with maintenance, the negative PNW for the low bound of the confidence interval (Table 16) shows it is far from a risk free proposition. But, with no added costs from environmental considerations, the rancher viewpoint remains economically feasible throughout the maintenance confidence interval (Table 16). In both cases, the maintenance scenario is vastly superior to the no maintenance scenario in terms of economic feasibility, given future prairie dog population growth.

The value of cattle forage used in this study (the lease opportunity of $12 per AUM in 1979) is a fairly accurate estimate of the costs avoided by ranchers faced with cutbacks in only one season of their seasonal forage supply, as might be caused by prairie dog invasion on summer range. This $12 value per AUM, however, is probably more than the net returns gained from increased beef production. While a detailed study of the net revenue gained from control by the ranching operations in the Conata basin would be the ideal in accuracy, such a study was not possible within the time and budget constraints. Thus, the simpler approach of valuing the forage gained from prairie dog control in terms of avoiding leasing other forage or in terms of what the forage gains could be leased for was accepted as a reasonable representation of the true value.

As the large negative PNWs show (Table 13), the USFS as a fiscal agent is clearly not acting as a profit maximizing entity when performing prairie dog control. This is not surprising since federal agencies generally act as agents of the sovereign when undertaking projects, which makes a cash-flow analysis represented in the fiscal agent analysis inappropriate for an economic evaluation of prairie dog control. This is because benefits are created from control which are not accounted for when only the grazing fee is used to value AUMs and not the full value of an AUM. The fiscal agent analysis does show, however, direct costs and returns from prairie dog control accruing to the federal treasury.

Other largely non-quantifiable or non-market benefits that might be claimed by the USFS as results of prairie dog control include improved range condition, decreased erosion, protection of private lands from the spread of prairie dogs, and a reduction in the potential of a plague outbreak.[7] The outbreak of a plague is possible, but this can only be considered a minor benefit because the remoteness of the Conata basin from any population center(s) suggests that the probability of a health hazard from any outbreak is small. Improved

[7] These same benefits would result from prairie dog control by ranchers, but they are not crucial in this viewpoint because control is already economically feasible.

range condition might be obtained if prairie dogs were controlled, however, the data in Table 20 indicates that production of cattle forage species as measured by the standing crop under cages showed no improvement after five years elimination. Thus, it is doubtful that improved range condition should be emphasized as a benefit in the first few years after control.

An estimate of the usable cattle forage gained from preventing the spread of prairie dogs is shown in Table 21. This estimate was generated by using the 1975 to 1977 data on cattle grazing only areas compared to cattle and prairie dog grazing areas (Table 33 in the appendix). The same method of evaluation, as detailed previously, was used. The 3-year average standing crop productions for cattle forage species on cattle grazing only areas and on cattle and prairie dog grazing areas were used to find the production changes due to prairie dog invasion. The amount of forage utilized by prairie dogs was estimated by multipling the 3-year average production for each cattle forage species on the cattle and prairie dog grazing areas times the same prairie dog utilization percentages used previously. Both of these figures were in lb/ac and were converted into usable cattle forage when multiplied by cattle use percentages.

For the six cattle forage species categories, there was a gain of 1 pound per acre resulting from preventing prairie dog invasion. When japanese brome (Bromus japonicus) is included, an additional 68 pounds of forage production per acre is gained. Retaining japanese brome is of questionable value because it is an annual grass with a limited period of spring grazing. Thus, it may be concluded from the available data that preventing the spread of prairie dogs has

Table 20. Comparison of the total cattle forage production as measured by standing crop production under cages on the three grazing treatments.

Year	No Grazing	Prairie Dog Grazing	Cattle and Prairie Dog Grazing
	pounds per acre		
1976	539	577	620
1977	472	576	657
1978	1185	634	853
1979	1093	1622	1318
4-year Average	822	852	862

Table 21. Usable cattle forage gained from preventing the spread of prairie dogs, 1975 to 1977 data on cattle grazing only areas compared to cattle and prairie dog grazing areas.

Category	Change in Herbage Production: cattle grazing minus cattle and prairie dog grazing	Herbage Production: cattle and prairie dog grazing	prairie dog use	cattle use		total usable cattle forage (lb/ac)
	—— pounds per acre ——					
Western wheatgrass						
production	(134-182)=-48			x 0.6	=	-35
prairie dog use		182	x 0.41	x 0.6	=	45
Blue grama and Buffalograss						
production	(270-375)=-105			x 0.4	=	-42
prairie dog use		375	x 0.09	x 0.4	=	14
Sun sedge						
production	(94-75)=19			x 0.6	=	11
prairie dog use		75	x 0.39	x 0.6	=	18
Other grasses						
production	(60-108)=-48			x 0.3	=	-14
prairie dog use		108	x 0.48	x 0.3	=	16
Scarlet globemallow						
production	(38-59)=-21			x 0.7	=	-15
prairie dog use		59	x 0.11	x 0.7	=	5
Black medick						
production	(1-14)=-13			x 0.5	=	-7
prairie dog use		14	x 0.70	x 0.5	=	5
						1
Japanese brome[a]						
production	(87-19)=68					

[a]No prairie dog utilization figure was available for this species.

no real benefit in the way of preventing declines in cattle forage.

Overall, it is doubtful that a prairie dog control program can be justified on the basis of benefits other than increased cattle forage. If control cannot be economically justified on the basis of improvements in cattle forage, any other benefits from controlling prairie dogs will probably not be of sufficient magnitude to provide justification for the program.

In addition to any non-market priced benefits that prairie dog control might generate, there are also costs of control which are difficult to price. Foremost among these would be a loss of black-footed ferret habitat and prairie dog sport shooting. Both of these costs have been mitigated by the USFS's control program through the retention of prairie dog towns for both purposes. No such retention was assumed from the rancher viewpoint because these costs would not accure to the rancher directly.[8]

For the loss of black-footed ferret habitat, it would be difficult to evaluate such a habitat loss, much less put a value on it, because the black-footed ferret was last sighted on the Conata basin in 1968.

While the USFS control program substantially reduces the number of prairie dog towns available for sport shooting, it does not eliminate them on the Conata basin. In the past, sport shooters have been allowed free access to the National Grassland because the supply of prairie dogs for sport shooting was much greater than

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[8]This is under the assumption that the difficulty of selling access rights to shoot prairie dogs plus the availability of free access to prairie dog towns on public lands makes the sport shooting value of prairie dogs essentially zero to ranchers.

the demand. This control program will not change the free access of sport shooters to the National Grassland, but any increased costs will be borne by the shooters in the form of increased search time for active prairie dog towns. When these two non-market costs are added together, they are small when compared to the dollar costs of the USFS control program.

With prairie dog control found to be economically feasible for the rancher and the USFS sovereign agent analyses under their maintenance scenarios, only in the case of the USFS as a fiscal agent must the non-market benefits outweight the non-market costs in order to make control economically feasible. In this case though, the effect would have to be substantial. If valued in dollars, the non-market benefits minus the non-market costs would have to have a PNW of at least $175,000 (Table 13) under the no maintenance scenario for control to be feasible. The required PNW rises to nearly $200,000 (Table 13) if maintenance is done so that it is very doubtful whether non-market considerations could push the USFS as a fiscal agent into the economic feasibility range.

The vegetation production data obtained by the USFS experiment station indicates that prairie dog control primarily results in increases in cattle forage production from cool-season grasses or grass-like plants. Sun sedge, which greens up early and provides good early season cattle forage (Johnson and Nichols, 1970), provides the major forage gains from prairie dog elimination. Also, japanese brome production declined with the invasion of prairie dogs (Table 21), though it is not particularly good cattle forage. This effect is supported in the literature. Koford (1958) observed that prairie dogs actively feed during April and May and that total food consumption is greatest shortly after the young prairie dogs come above ground, usually in May.

On the other hand, western wheatgrass (an important cool-season grass) showed no production increase due to prairie dog control (Table 24 in the appendix). Western wheatgrass, a desirable mid-grass cattle forage species, produces more forage than the dominant shortgrasses. One goal of improved range management on the mixed grass prairie is to increase mid-grass production, which prairie dog control does not accomplish.

The future annual maintenance acres estimated in this study of 1350 acres for the USFS and 360 acres for the rancher are rough projections of the future prairie dog control necessary to maintain the project. The actual maintenance acres required to control prairie dog re-invasion could be substantially smaller or larger. Table 22 shows a range of economic feasibility for prairie dog control from no required maintenance because of zero projected growth in prairie dog infested acres to the maximum annual maintenance acres in which control is still feasible from each viewpoint.

The maximum annual maintenance acres of 1395 for the USFS as a sovereign agent viewpoint and 3060 acres for the rancher viewpoint were estimated by increasing the maintenance acreage until the PNW was just above zero. By increasing the maintenance acreage, annual costs rise by $5 per acre for the ranchers and by $5.50 per acre for the USFS, and a decrease of one AUM of cattle forage results from every 9.5 acre increase in maintenance acreage. With a maximum annual

Table 22. The economic feasibility of prairie dog control from two management viewpoints under three maintenance scenarios.

	No Maintenance zero growth		With Maintenance 30 percent growth		Maximum Maintenance Acres	
Viewpoint	PNW ($)	year positive benefits begin	PNW ($)	year positive benefits begin	PNW ($)	year positive benefits begin
Rancher	132,846	1989	109,011	1990	130	2013
USFS as an agent of the sovereign	72,393	1993	2587	2011	250	2012

maintenance of 3060 acres for the rancher viewpoint, annual costs of control would be $15,300 starting in 1982. The 2700 acre increase (3060 - 360) in maintenance control results in 284 AUMs (2700 divided by 9.5) less each year starting in 1983. This decreases the constant annual benefits from $40,560 (Table 11) to $37,150.

The maximum maintenance acres are approximately 5 percent of the total initially controlled by the USFS (29,168) and 9 percent of the total acres assumed to be controlled by the ranchers (33,668). If the annual required maintenance control is greater than 5 percent of 29,168 acres for the USFS or 9 percent of 33,668 acres for the ranchers, prairie dog control will not be economically feasible. This is not meant to imply that annual maintenance of 5 percent or 9 percent of the initially controlled acreage will be adequate to prevent prairie dog re-invasion, but it does provide guidelines as to the upper limits of projected maintenance under which control can be expected to be economically feasible.

If no future growth in the prairie dog towns is projected, only the viewpoint of the USFS as an agent of the sovereign changes substantially in the economic analysis when compared to the maintenance scenario projected in this study. The year when positive benefits start to accure makes a major change with this analysis from 2011 to 1993. This was calculated by reducing the length of the stream of constant annual benefits by one year increments until the positive PNW was just above zero. For example, the USFS as an agent of the sovereign viewpoint with maintenance did not begin to to accure positive benefits until 2011. If the constant annual return of $34,104 minus $7425 (Table 12) was decreased one more year to end in 2010, the control program would have a negative PNW. Elimination of the high maintenance cost in this viewpoint ($7425 per year) and its marginal feasibility to begin with would mean that the potential for improvement from an economic standpoint would be much improved.

With no future growth projected, no prairie dog control would be assumed to occur after the end of the 1980 control season for the USFS viewpoint and none after the end of the 1981 control season for the rancher viewpoint. The maximum acres with increased cattle forage for the USFS viewpoint would begin in 1982 with 28,300 acres (2979 AUMs) and continue thereafter for 30 years. From the rancher viewpoint, 32,650 acres (3437 AUMs) would begin in 1983 and continue for the 30 year project life.

Little or no future growth in the prairie dog populations left behind on the National Grassland of the Conata basin after control ceases would probably occur if reductions were made in the stocking rates and/or changes were made in the grazing systems in practice before control. Whether the actual cuts in livestock permits that accompanied prairie dog control in the EIS are sufficient to prevent rapid expansion of prairie dogs again remains to be seen. In any case, the costs of reducing livestock grazing or possibly implementing grazing systems to prevent prairie dog re-invasion are not accounted for in this study and would have to be included in any no growth projection scenario to make it realistic.

SUMMARY AND CONCLUSIONS

In this study, prairie dog control resulted in cattle forage gains mainly from improvements in available shortgrass forage. While prairie dog control was deemed economically feasible due to the cattle forage gained, the data did not indicate that control caused a shift in grass production towards mid-grasses. The concensus in the literature is that prairie dogs increase shortgrasses and decrease mid-grasses. This study found no recovery of western wheatgrass to be apparent over the five years prairie dogs were exluded from the no grazing exclosures. This does not imply that western wheatgrass production will not increase on prairie dog eliminated areas compared to production on prairie dog grazing areas in the future. This increase, however, may be too far into the future to be of much value from an economic standpoint.

From the viewpoint of the USFS acting as an agent of the sovereign, the economic feasibility of prairie dog control by federal agencies on federal lands is marginal at best. The added costs of the various environmental considerations mandated by federal regulations mean that prairie dog control has a much greater chance of returning a negative PNW and requires continued maintenance to even come close to paying off. On the other hand, the rancher viewpoint shows that control on private lands with no environmental considerations taken into account is economically feasible with or without maintenance control. When maintenance is included, control on private land has a very low risk of returning a negative PNW since only positive PNWs occur throughout its confidence interval.

In both viewpoints, annual maintenance control to prevent prairie dog re-invasion is almost essential to insure economic feasibility given the possibility of future growth in prairie dog populations. But, the annual maintenance acres in the future must be below 5 percent for the USFS and 9 percent for the ranchers of the total initially controlled acreage in order for prairie dog control to remain economically feasible.

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APPENDIX

Table 23. Blue grama and buffalograss August standing crop production figures and prairie dog utilization computation.

-Clipped Under Cages-

	No Grazing Exclosures				Prairie Dog Grazing Exclosures			
Year	A	H	K	Ave.	C	F	M	Ave.
	pounds per acre							
1976	297	142	215	218	183	212	377	257
1977	330	149	155	211	489	187	211	296
1978	597	372	427	465	479	251	395	375
1979	731	287	820	613	1213	703	627	848
4-year average				377				444
1978-1979 average								611

-Clipped Outside of Cages-

Year	C	F	M	Ave.
	pounds per acre			
1978	500	232	396	376
1979	1017	558	558	711
				544

-Prairie Dog Utilization-

$$611 - 544 = 57$$

$$\frac{57}{611} \times 100 = 9\%$$

Table 24. Western wheatgrass standing crop production figures. August data used in averaging unless the June data significantly larger statistically.

-Clipped Under Cages-

Year	No Grazing Exclosures A	H	K	Ave.	Prairie Dog Grazing Exclosures C		F		M		Ave.
	pounds per acre										
1976	33	138	10	60	173		23		26		74
1977	3	27	4	11	202		15		19		79
					June	Aug.	June	Aug.	June	Aug.	
1978	10	193	10	71	135	16[a]	4	2[a]	7[a]	0	8
1979	17	57	8	27	58	89[a]	23	6[a]	1	46[a]	47
4-year average				42							52
1978-1979 average											
June											38
August											27

-Clipped Outside of Cages-

Year	C June	C Aug.	F June	F Aug.	M June	M Aug.	Ave. June	Ave. Aug.
	pounds per acre							
1978	41	30	18	7	2	0	20	12
1979	77	38	0	4	3	16	27	19
							24	16

-Prairie Dog Utilization-

June	August
$38 - 24 = 14$	$27 - 16 = 11$
$\frac{14}{38} \times 100 = 38\%$	$\frac{11}{27} \times 100 = 41\%$

[a]used in yearly averaging

Table 25. Sun sedge standing crop production figures. August data used in averaging unless the June data significantly larger statistically.

-Clipped Under Cages-

Year	No Grazing Exclosures A	H	K	Ave.	Prairie Dog Grazing Exclosures C		F		M		Ave.
					pounds per acre						
1976	115	222	94	144	25		160		66		84
1977	137	231	78	149	10		89		71		57
					June	Aug.	June	Aug.	June	Aug.	
1978	144	414	129	229	20	11[a]	85	53[a]	75[a]	35	46
1979	111	435	48	198	26	48[a]	122	97[a]	158	96[a]	80
4-year average				180							67
1978-79 average											
June											81
August											57

-Clipped Outside of Cages-

Year	C June	C Aug.	F June	F Aug.	M June	M Aug.	Ave. June	Ave. Aug.
	pounds per acre							
1978	11	5	79	43	47	14	46	21
1979	14	36	111	66	43	45	56	49
							51	35

-Prairie Dog Utilization-

June

$81 - 51 = 30$

$\frac{30}{81} \times 100 = 37\%$

August

$57 - 35 = 22$

$\frac{22}{57} \times 100 = 39\%$

[a]used in yearly averaging

Table 26. Standing crop production figures for the other grasses category[a]. Mostly August data used although some June data were included for annual grasses if larger.

-Clipped Under Cages-

Year	No Grazing Exclosures				Prairie Dog Grazing Exclosures			
	A	H	K	Ave.	C	F	M	Ave.
	pounds per acre							
1976	1	147	21	56	137	51	17	68
1977	1	128	14	47	123	44	8	58
1978	29	388	378	265	152	95	25	91
1979	3	624	24	216	540	542	40	374
4-year average				146				148
1978-79 average								233

-Clipped Outside of Cages-

Year	C	F	M	Ave.
	pounds per acre			
1978	141	92	1	78
1979	348	136	2	162
				120

-Prairie Dog Utilization-

$$233 - 120 = 113$$

$$\frac{113}{233} \times 100 = 48\%$$

[a]Major grasses in this category are: sixweeks fescue (Festuca octoflora), crested wheatgrass (Agropyron cristatum), threeawn (Artistida longiseta), and tumblegrass (Schedonnardus paniculatus). Other minor grasses include green needlegrass (Stipa veridula), sand dropseed (Sporobolus cryptandrus), and japanese brome (Bromus japonicus).

Table 27. Scarlet globemallow standing crop production figures. The largest of the June or August production figures were used.

-Clipped Under Cages-

Year	No Grazing Exclosures: A	H	K	Ave.	Prairie Dog Grazing Exclosures: C		F		M		Ave.
	pounds per acre										
1976	29	32	87	49	67		33		130		76
1977	18	38	106	54	51		78		117		82
					June	Aug.	June	Aug.	June	Aug.	
1978	15	25	60	33	111[a]	15	10	11[a]	95[a]	7	72
1979	41	11	65	39	115	118[a]	67[a]	4	175	218[a]	134
4-year average				44							91
1978-79 average											
June											96
August											62

-Clipped Outside of Cages-

Year	C June	C Aug.	F June	F Aug.	M June	M Aug.	Ave. June	Ave. Aug.
	pounds per acre							
1978	134	15	23	53	85	62	81	43
1979	125	130	34	53	106	59	88	81
							85	62

-Prairie Dog Utilization-

June	August
96 - 85 = 11	62 - 62 = 0
$\frac{11}{96} \times 100 = 11\%$	0%

[a]used in yearly averaging

Table 28. Black medick standing crop production figures. The largest of the June or August production figures were used.

-Clipped Under Cages-

	No Grazing Exclosures				Prairie Dog Grazing Exclosures						
Year	A	H	K	Ave.	C		F		M		Ave.
	pounds per acre										
1976	15	4	0	6	27		0		0		27
1977	0	0	0	0	7		0		0		2
					June	Aug.	June	Aug.	June	Aug.	
1978	60	307	0	122	125[a]	8	0	1[a]	0	0	42
1979	0	0	0	0	0	418[a]	0	0	0	0	139
4-year average				32							48
1978-79 average											
June											21
August											71

-Clipped Outside of Cages-

	C		F		M		Ave.	
Year	June	Aug.	June	Aug.	June	Aug.	June	Aug.
	pounds per acre							
1978	59	2	0	0	0	0	20	1
1979	0	80	0	0	0	5	0	28
							10	15

-Prairie Dog Utilization-

June

$21 - 10 = 11$

$\frac{11}{21} \times 100 = 52\%$

August

$71 - 15 = 56$

$\frac{56}{71} \times 100 = 70\%$

[a]used in yearly averaging

Table 29. The estimated cost for preparing the USFS Environmental Impact Statement on the management of prairie dogs.

Item	Days		Costs per Day ($)		Total
GS-12 Range & Wildlife Staff Officer Principle Author	80	x	109	=	$8720
GS-11 Wildlife Biologist Data Collection	40	x	91	=	$3640
GS-12 Ranger Review and Comments	3	x	109	=	$327
GS-11 Ranger Review and Comments	3	x	91	=	$273
GS-12, 13, 14, and 15 Regional Forester Staff Review Process	4	x	134	=	$536
GS-3 Typist	20	x	27	=	$540
GS-13 Supervisor Review and Comments	2	x	130	=	$260
					$14,296
Printing Cost - Draft and Final					$1000
					$15,296

Source: Lees (1980)

Table 30. The pooled variances from the vegetation sampling on three no grazing and three prairie dog grazing exclosures and the yearly bound of error at the 95 percent confidence interval for the other grasses and blue grama and buffalograss categories.

-Blue Grama and Buffalograss-

	No Grazing Variances				Prairie Dog Grazing Variances			
Year	A	H	K	Bound of error (±)	C	F	M	Bound of error (±)
1976	21,161	17,096	10,406	22	16,213	18,871	9010	21
1977	28,330	12,773	5676	22	45,826	17,636	8390	27
1978	67,355	126,596	95,011	124	147,712	45,448	48,199	100
1979	26,885	72,004	104,115	104	645,361	378,847	71,932	214

-Other Grasses-

Year	A	H	K	Bound of error (±)	C	F	M	Bound of error (±)
1976	0	58,651	94	25	30,228	1541	76	18
1977	19,471	21,455	481	21	15,881	9126	41	16
1978	1251	301,773	10,482	129	42,213	12,502	1679	49
1979	0	359,173	2315	139	681,956	313,490	6801	231

Table 31. Variances and the yearly bound of error at the 95 percent confidence interval for four cattle forage species categories.

-Western Wheatgrass-

	No Grazing Variances				Prairie Dog Grazing Variances			
Year	A	H	K	Bound of error (±)	C	F	M	Bound of error (±)
1976	3099	79,647	503	29	22,455	1506	3042	17
1977	41	4408	376	7	86,663	1115	2274	31
1978	321	66,431	396	60	704	57	445	7
1979	1331	2820	118	15	16,552	223	6532	31

-Sun Sedge-

Year	A	H	K	Bound of error (±)	C	F	M	Bound of error (±)
1976	4508	4106	5178	12	622	6479	2319	10
1977	4947	27,442	1466	19	343	5126	1877	9
1978	2253	10,863	8990	34	343	1189	1077	10
1979	12,932	20,056	1344	42	4635	10070	3327	27

-Scarlet Globemallow-

Year	A	H	K	Bound of error (±)	C	F	M	Bound of error (±)
1976	1588	3248	8135	12	11,006	2986	20,813	19
1977	1355	3624	5857	11	4391	11574	8210	16
1978	507	1735	2689	16	16,826	428	6742	32

Table 31. Continued

-Scarlet Globemallow-

Year	A	H	K	Bound of error (±)	C	F	M	Bound of error (±)
1979	3201	262	3548	19	29,216	5924	27,154	51

-Black Medick-

Year	A	H	K	Bound of error (±)	C	F	M	Bound of error (±)
1976	534	222	0	3	1715	1	0	4
1977	0	2	0	0	334	0	0	2
1978	2532	327,011	0	133	30,832	2	0	36
1979	0	0	0	0	556,664	0	0	153

Table 32. 95 percent confidence interval equations for breakeven prairie dog control costs per acre (Y) given AUM values (X).

Viewpoints	With Maintenance	Without Maintenance
USFS		
high	Y = 0.692X - 0.40	Y = 0.477X - 0.51
low	Y = 0.343X - 0.40	Y = 0.237X - 0.51
Rancher		
high	Y = 0.882X	Y = 0.614X
low	Y = 0.438X	Y = 0.305X

Table 33. Average standing crop production of cattle forage species clipped under cages from cattle grazing only areas and from cattle and prairie dog grazing areas.

Year	Western wheat-grass	Sun sedge	Blue grama & Buffalograss	Japanese brome	Other grasses	Scarlet globe-mallow	Black medick
				Cattle Grazing			
	pounds per acre						
1975	178	131	455	74	93	32	1
1976	70	90	167	98	67	24	1
1977	153	62	189	89	19	59	0
3-year Ave.	134	94	270	87	60	38	1
				Cattle and Prairie Dog Grazing			
1975	216	69	638	14	187	57	27
1976	126	76	216	35	98	63	10
1977	204	81	270	8	39	56	4
3-year Ave.	182	75	375	19	108	59	14